

## DOUBLE-SIDED METALLIC LAMINATE AND METHOD FOR MANUFACTURING THE SAME

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### Technical Field

The present invention relates to a double-sided metallic laminate for a printed circuit board and a method  
10 for manufacturing the same, and more particularly, a metallic laminate for a circuit board comprising, between two metallic layers, a resin layer of a low expansion polyimide and a resin layer of a thermoplastic polyimide; or a resin layer of a polyimide for improving adhesion with  
15 a metal, a resin layer of a low expansion polyimide and a resin layer of a thermoplastic polyimide, which has excellent flexibility and thermal resistance, prevents the formation of curl and is securely laminated without the use of an additional adhesive.

20

### Background Art

For small size and multi-functions of electric appliances, particularly for lightness, thinness, shortness  
25 and small size of portable appliances, there is a demand

for high density of a circuit board used in electric appliances and generally, a circuit board is made in a multi-layered structure to meet the demand. Also, a flexible printed circuit base board may be used to be  
5 installed in a limited space or a circuit with a narrow line width may be used to produce a large amount of circuits in the same space. Meanwhile, considering the environmental problems caused by soldering for the multi-layered structure, concern about an adhesive to produce the  
10 multi-layered structure without using lead is increased and there is a demand for an adhesive with high adhesion, high thermal resistance and low moisture absorption for a circuit board.

The conventional metallic laminate comprising a  
15 polyimide film and a metal foil adhered to each other by an acryl or epoxy adhesive is not adequate for a circuit board requiring a multi-layered structure, flexibility, high adhesive power and high thermal resistance. Therefore, there has been developed an adhesive free type flexible  
20 metallic laminate which is produced by directly adhering a polyimide and a metal foil without using an adhesive.

Meanwhile, for a high density circuit, a circuit board of a double-sided metallic laminate comprising metal foils laminated at both sides of a polyimide resin is  
25 preferred.

Japanese Patent Laid-Open Publication No. Heil-244,841 discloses a method for preparing a double-sided metallic laminate for a printed circuit board using a thermoplastic polyimide having a glass transition  
5 temperature exceeding 250°C. Therefore, it has problems in that the lamination of the thermoplastic polyimide on a metal foil is performed under a condition including a high temperature of over 350°C and a high pressure of over 50 kg/cm<sup>2</sup>.

10 Also, US PAT NO. 5,112,694 discloses a double-sided metallic laminate, in which a single layer of a polyimide is coated on a metal foil and another metal foil is laminated thereto at a temperature of over 380°C and a pressure of 20 kg/cm or more. However, this double-sided  
15 metallic laminate has problems in that it should be subjected to a high temperature and high pressure condition.

#### Disclosure of Invention

20 Accordingly, the present invention has been made in order to solve the foregoing problems, and it is an object of the present invention to provide a metallic laminate for a circuit board securely laminated without the use of an additional adhesive which has high density, flexibility and  
25 thermal resistance while preventing curl which often occurs

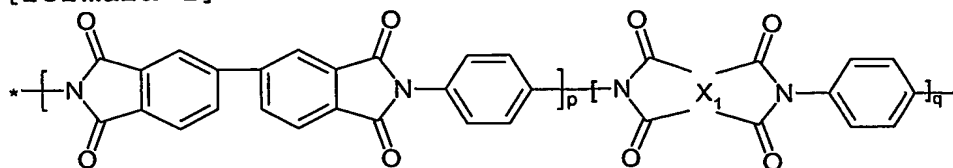
on a laminated board.

It is another object of the present invention to provide a method for manufacturing a metallic laminate for a circuit board securely laminated without the use of an additional adhesive which has high density, flexibility and thermal resistance while preventing curl which often occurs on a laminated board.

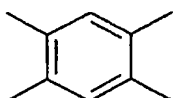
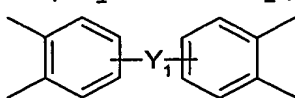
In order to achieve the above objects, the present invention provides a double-sided metallic laminate comprising a metallic layer at one side, a resin layer of a low expansion polyimide having a thermal expansion coefficient of  $5 \times 10^{-6}$  to  $2.5 \times 10^{-5}/^{\circ}\text{C}$ , a resin layer of a thermoplastic polyimide and a metallic layer at the other side.

The low thermal expansion polyimide may be the following formula 1.

[formula 1]



In the formula 1,  $p > 1$ ,  $q > 0$  and  $p/q = 0.4 \sim 2.5$ ,

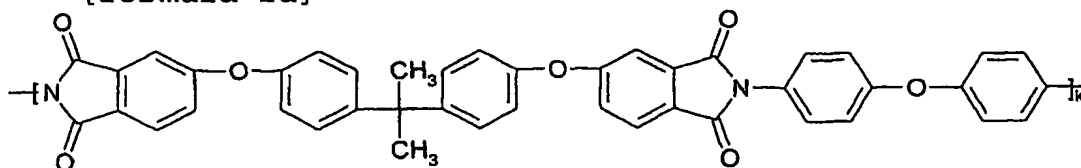
$X_1$  is  or , and

$Y_1$  is  $-\text{O}-$  or  $-\text{CO}-$ .

The thermoplastic polyimide may have a glass transition temperature of 200 to  $250^{\circ}\text{C}$ .

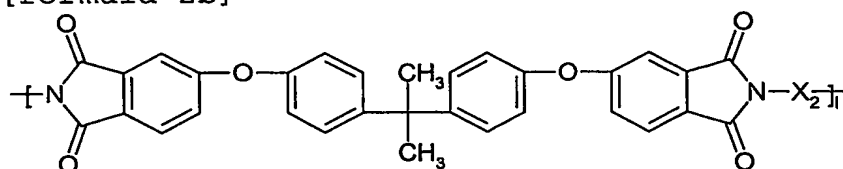
The thermoplastic polyimide may be a copolymer including the following formula 2a, formula 2b, formula 2c and formula 2d.

[formula 2a]

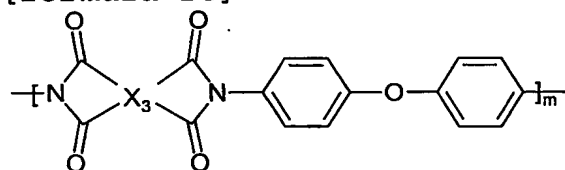


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[formula 2b]

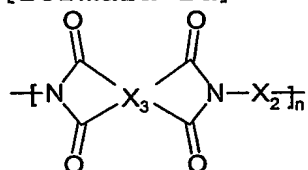


[formula 2c]



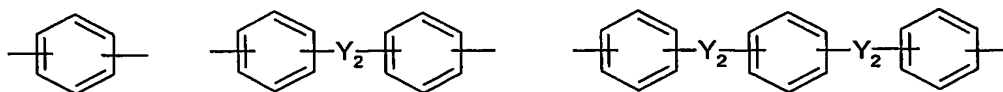
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[formula 2d]



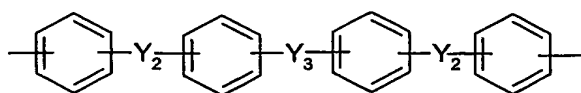
In the formulae 2a to 2d,  $k \geq 1$ ,  $l, m, n \geq 0$ ,  $l = m = n \neq 0$ ,  $k \geq l$ ,  $k + l > 1.5(m + n)$  and  $k + m > 1.5(l + n)$ ,

$X_2$  is at least one selected from the group consisting



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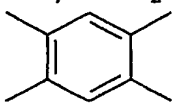
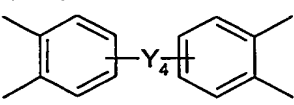
of



and

$Y_2$  and  $Y_3$  are each independently or simultaneously -,

-O-, -CO-, -S-, -SO<sub>2</sub>-, -C(CH<sub>3</sub>)<sub>2</sub>- or -CONH-,

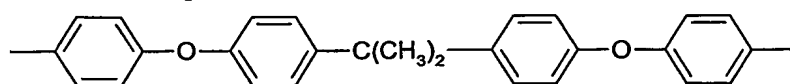
X<sub>3</sub> is  or , and

Y<sub>4</sub> is -, -O- or -CO-.

The thermoplastic polyimide may be the formulae 2a to

5 2d, in which m, n= 0 and X<sub>2</sub> is the following formula 3.

[formula 3]

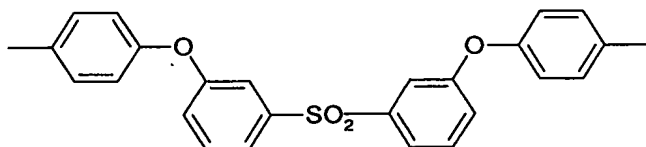


The thermoplastic polyimide may be the formulae 2a to

2d, in which m, n=0 and X<sub>2</sub> is the following formula 4.

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[formula 4]



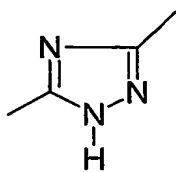
The metallic layer may be formed of copper.

The double-sided metallic laminate may further comprise a resin layer of a polyimide between the metallic layer at one side and a resin layer of a low expansion polyimide for improving adhesion with a metal.

The polyimide for improving adhesion with a metal is a polyimide having a -NH- functional group introduced.

The polyimide for improving adhesion with a metal is  
20 a polyimide having the following formula 5 introduced.

[formula 5]

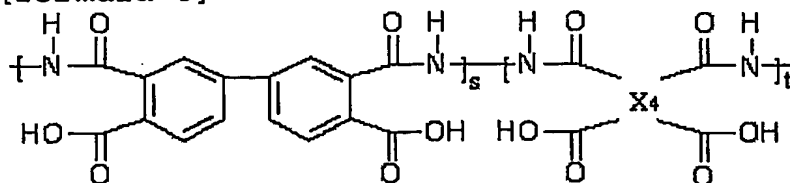


The polyimide for improving adhesion with a metal is a copolymer including the formula 2a, formula 2b, formula 2c and formula 2d.

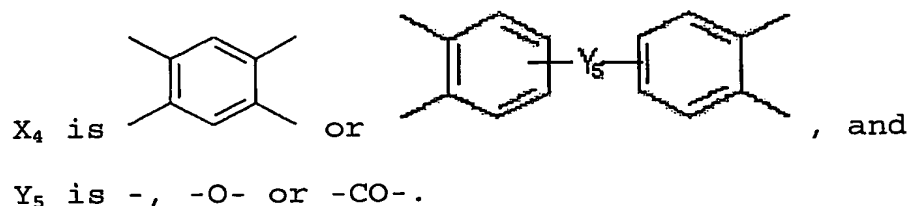
5 Also, the present invention provides a method for manufacturing a double-sided metallic laminate comprising simultaneously or sequentially applying a precursor of a low thermal expansion polyimide having a thermal expansion coefficient of  $5 \times 10^{-6}$  to  $2.5 \times 10^{-5}/^{\circ}\text{C}$  and a precursor of a  
10 thermoplastic polyimide on a metal foil to form one side of the double-sided metallic layer, followed by drying and curing, and laminating another metal foil on the resin layer of a thermoplastic polyimide of the resulting one-sided metallic laminate comprising a metal foil layer, a  
15 resin layer of a low expansion polyimide and a resin layer of a thermoplastic polyimide, which are sequentially laminated, to form the other side of the double-sided metallic laminate.

The precursor of a low thermal expansion polyimide  
20 may be a copolymer of the following formula 6.

[formula 6]



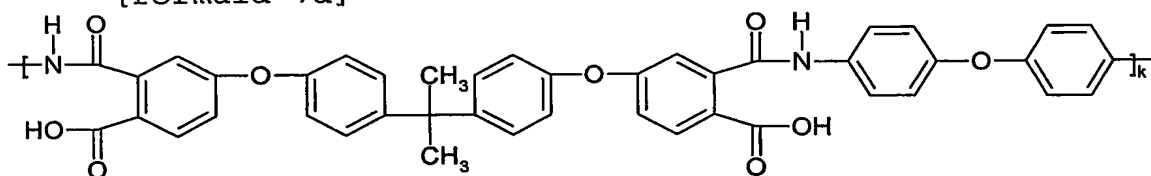
In the formula 6,  $s > 1$ ,  $t > 0$  and  $s/t = 0.4 \sim 2.5$ ,



The thermoplastic polyimide may have a glass transition temperature of 200 to 250°C.

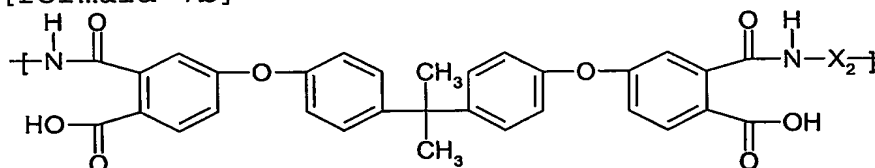
The precursor of a thermoplastic polyimide may be a copolymer including the following formula 7a, formula 7b, formula 7c and formula 7d.

[formula 7a]

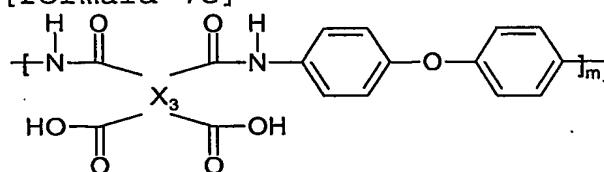


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[formula 7b]

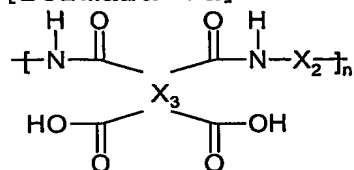


[formula 7c]



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[formula 7d]

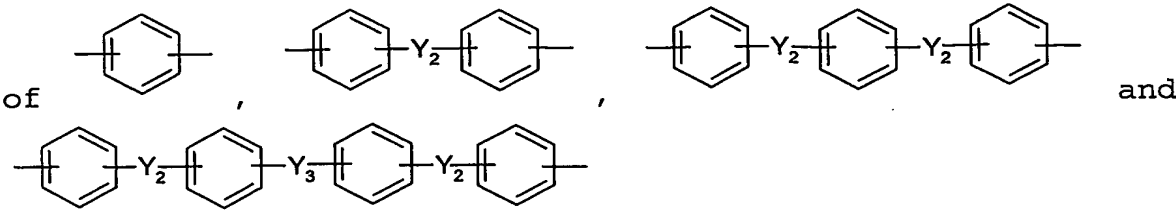


In the formulae 7a to 7d,  $k \geq 1$ ,  $l, m, n \geq 0$ ,  $l = m = n \neq 0$ ,



$\geq \ell$ ,  $k + \ell > 1.5(m+n)$  and  $k+m > 1.5(\ell + n)$ ,

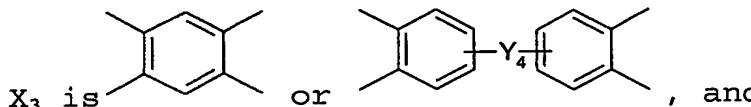
$X_2$  is at least one selected from the group consisting of



and

5  $Y_2$  and  $Y_3$  are each independently or simultaneously -, -O-, -CO-, -S-, -SO<sub>2</sub>-, -C(CH<sub>3</sub>)<sub>2</sub>- or -CONH-,

$X_3$  is



or , and

$Y_4$  is -, -O- or -CO-.

The precursor of a thermoplastic polyimide may be the  
10 formulae 7a to 7d, in which  $m$ ,  $n=0$  and  $X_2$  is the formula 3.

The precursor of a thermoplastic polyimide may be the  
formulae 7a to 7d, in which  $m$ ,  $n=0$  and  $X_2$  is the formula 4.

The precursor applied on the metal film at one side  
of the double-sided metallic layer may be a precursor of a  
15 polyimide for improving adhesion with a metal, precursor of  
a low thermal expansion polyimide having a thermal  
expansion coefficient of  $5 \times 10^{-6}$  to  $2.5 \times 10^{-5}/^\circ\text{C}$  and a  
precursor of a thermoplastic polyimide.

The precursor of a polyimide for improving adhesion  
20 with a metal is a precursor of a polyimide having a -NH-  
functional group introduced.

The precursor of a polyimide for improving adhesion  
with a metal is a precursor of a polyimide having the

formula 5 introduced.

The precursor of a polyimide for improving adhesion with a metal is a copolymer including formula 7a, formula 7b, formula 7c and formula 7d.

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#### Brief Description of Drawings

Further objects and advantages of the invention can be more fully understood from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. 1 schematically shows the process for preparing a double-sided metallic laminate by sequentially laminating a metal foil layer 1 of one side, a resin layer of a low expansion polyimide 3, a resin layer of a thermoplastic polyimide 4 and a metal foil layer 5 of the other side, according to the present invention; and

FIG. 2 schematically shows the process for preparing a double-sided metallic laminate by sequentially laminating a metal foil layer 1 of one side, a resin layer of a polyimide 2 to increase the adhesion, a resin layer of a low expansion polyimide 3, a resin layer of a thermoplastic polyimide 4 and a metal foil layer 5 of the other side, according to the present invention.

25

### Best Mode for Carrying Out the Invention

Now, the present invention will be described hereinafter in detail.

5       The double-sided metallic laminate according to the present invention is to provide a circuit board for a high density printed circuit board having flexibility and thermal resistance so that it can be installed in a limited space, which comprises polyimide type resin layers  
10 laminated between two metallic layers. Particularly, in order to provide a circuit board which prevents curl and is securely laminated without the use of an adhesive, it is characterized in that a resin layer of a low expansion polyimide and a resin layer of a thermoplastic polyimide  
15 are laminated between two metallic layers.

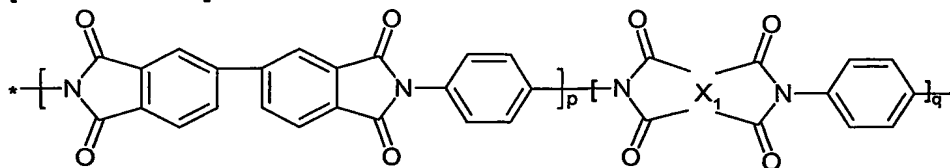
According to the present invention, polyimide type resin layers are selected to provide a metallic laminate having excellent flexibility and thermal resistance so that it can be installed in a limited small space.

20       Also, in order to prevent curl which may occur on the metallic laminate, the resin layer has a thermal expansion coefficient similar to that of the metal layer. Therefore, the resin layer which is laminated on the metallic layer according to the present invention is a low thermal  
25 expansion polyimide having a thermal expansion coefficient

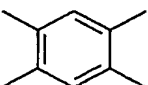
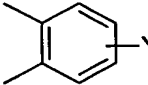
of  $5 \times 10^{-6}$  to  $2.5 \times 10^{-5}/^{\circ}\text{C}$ . If the low thermal expansion polyimide has a thermal expansion coefficient of less than  $5 \times 10^{-6}/^{\circ}\text{C}$ , when only one side of the metallic layers is etched, curl with the inside being the metallic layer occurs. If the thermal expansion coefficient exceeds  $2.5 \times 10^{-5}/^{\circ}\text{C}$ , when only one side of the metallic layers, curl with the inside being the resin layer occurs. Also, the resin layer of a low expansion polyimide is adhesive before curing into an insulating layer and thus, can be applied on the metal film without an additional adhesive.

The low thermal expansion polyimide is not particularly limited, as long as it has a thermal expansion coefficient of  $5 \times 10^{-6}$  to  $2.5 \times 10^{-5}/^{\circ}\text{C}$ , but is preferably a polyimide of the following formula 1 due to its low moisture absorption.

[formula 1]



In the formula 1,  $p > 1$ ,  $q > 0$  and  $p/q = 0.4 \sim 2.5$ ,

$X_1$  is  or , and

$Y_1$  is  $-\text{O}-$  or  $-\text{CO}-$ .

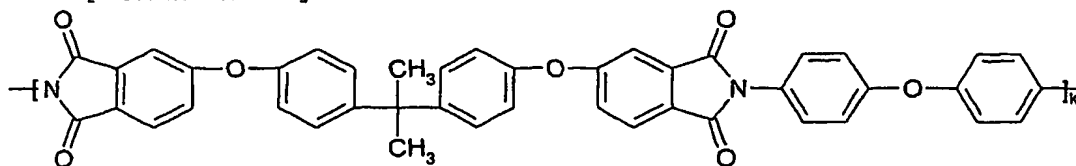
In the formula 1, if  $p/q$  is less than 0.4, the polyimide is too hard to be suitable for a flexible circuit board to be used in a limited place. Also, since the

thermal expansion coefficient exceeds  $2.5 \times 10^{-5}/^{\circ}\text{C}$ , when the one side of the metallic layer is etched, curl with the inside being the resin layer occurs. If  $p/q$  exceeds 2.5, the polyimide resin layer is easy to break. Also, since  
 5 the thermal expansion coefficient is excessively great, when the one side of the metallic layer is etched, curl with the inside being the metallic layer occurs.

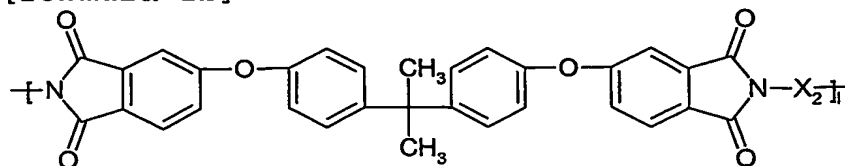
The above-described low thermal expansion polyimide has a glass transition temperature ( $T_g$ ) of  $400^{\circ}\text{C}$  or higher.  
 10 Therefore, it should be elevated to a temperature of over that to laminate in a metal foil. However, it is difficult to elevate the temperature of a lamination machine to over  $400^{\circ}\text{C}$  and moreover, the polyimide may be decomposed at a temperature of over  $400^{\circ}\text{C}$ . Therefore, the present  
 15 invention employs a thermoplastic polyimide resin layer having a glass transition temperature of 200 to  $250^{\circ}\text{C}$ , in addition to the low thermal expansion polyimide resin layer.

The thermoplastic polyimide is not particularly limited as long as it has a glass transition temperature of  
 20 200 to  $250^{\circ}\text{C}$ , but is preferably a copolymer including the formulae 2a, 2b, 2c and 2d since the adhesion requirement is not complicated and the adhesion is excellent.

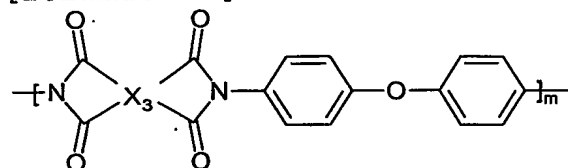
[formula 2a]



[formula 2b]

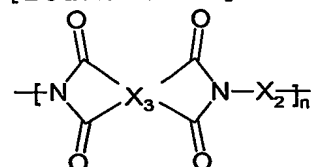


[formula 2c]



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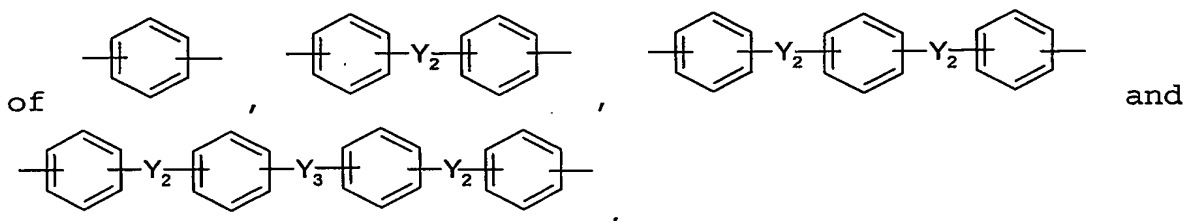
[formula 2d]



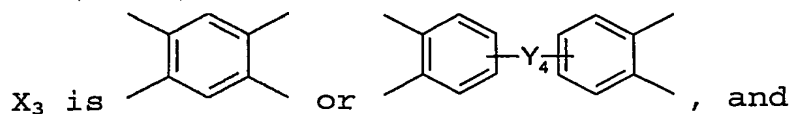
In the formulae 2a to 2d,  $k \geq 1$ ,  $\ell$ ,  $m$ ,  $n \geq 0$ ,  $\ell = m = n \neq 0$ ,  
 $k \geq \ell$ ,  $k + \ell > 1.5(m + n)$  and  $k + m > 1.5(\ell + n)$ ,

$X_2$  is at least one selected from the group consisting

10



$Y_2$  and  $Y_3$  are each independently or simultaneously -,  
 -O-, -CO-, -S-, -SO<sub>2</sub>-, -C(CH<sub>3</sub>)<sub>2</sub>- or -CONH-,



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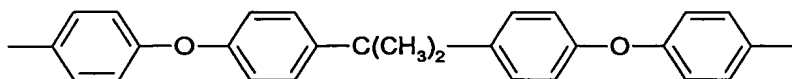
$Y_4$  is -, -O- or -CO-.

The reason why  $\ell = m = n \neq 0$  is that if  $\ell$ ,  $m$  and  $n$  are simultaneously 0, the fluidity of the thermoplastic polyimide is deteriorated, whereby the temperature of the

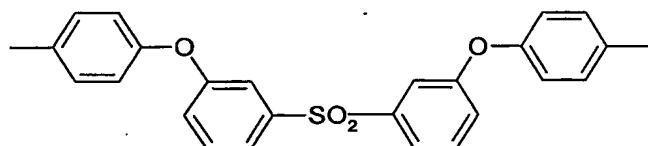
lamination process is raised and the rate is reduced. Also, the reason why  $k \geq \ell$ ,  $k + \ell > 1.5(m+n)$  and  $k+m > 1.5(\ell+n)$  is that if  $k < \ell$  or  $k+m > 1.5(\ell+n)$ , the thermoplastic polyimide has the chemical resistance deteriorated and thereby, is not suitable for a resin layer of a metallic laminate for a circuit board, while if  $k + \ell < 1.5(m+n)$ , the glass transition temperature is raised to over 250°C and thereby, the lamination with the metal is non-efficient.

The thermoplastic polyimide is more preferably a copolymer of the formulae 2a to 2d, in which  $m, n = 0$  and  $X_2$  is the formula 3 or a copolymer of the formulae 2a to 2d, in which  $m, n=0$  and  $X_2$  is the formula 4.

[formula 3]



[formula 4]



A monomer for a resin layer of the above described low expansion polyimide and a resin layer of the above-described thermoplastic polyimide may be at least one selected from the group consisting of tetracarboxylic acid dianhydrides such as pyromellitic acid dianhydride (PMDA), 3,3',4,4'-biphenyl tetracarboxylic acid dianhydride (BPDA), 4,4'-oxy di-(phthalic acid anhydride) (ODPA), 3,3',4,4'-

benzophenon-tetracarboxylic acid dianhydride (BTDA) and trimellitic acid ethylene glycol dianhydride (TMEG). Also, it may be at least one selected from the group consisting of aromatic diamines such as 1,3-phenyldiamine (MPDA),  
5 3,4'-oxi-dianiline (3,4'-ODA), 4,4'-diaminobenzanilid (DABA), 3,3'-dihydroxy-4,4'-diaminobiphenyl (HAB), 1,4-di(4-aminophenyl)butane (DAPB), 1,3-bis(3-aminophenoxy)benzene (APB), 4,4'-(1,3-phenylene diisopropylidene)dianiline (PDPDA), 2,2-bis[4-(4-aminophenoxy)phenyl]propane (BAPP) and bis([4-(3-aminophenoxy)phenyl]sulfone (BAPSM)).  
10

Also, the double-sided metallic laminate according to the present invention may further comprise an additional adhesive layer between the metal layer at one side and the  
15 resin layer of a low expansion polyimide to further improve the adhesion of the metallic layer at one side and a resin layer of a low expansion polyimide. By the inclusion of the additional adhesive layer it is possible to simultaneously improve the properties such as size  
20 stability, moisture absorption, adhesion and the like, which are required for a flexible printed-circuit board.

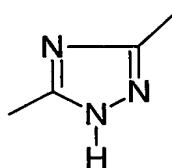
The adhesive layer to improve the adhesion to the metal may be a resin layer of a polyimide containing a functional group having an affinity for the metal or a  
25 resin layer which can readily flow into the prominence and



depression of the metal upon the lamination on the metal to be mechanically engaged with the metal.

It is known that the functional group having an affinity for the metal is -NH- group. Therefore, according to the present invention, the resin layer to improve the adhesion to the metal is preferably formed of a polyimide containing a -NH- group, more preferably a polyimide having the formula 5 introduced.

[formula 5]



Also, the resin layer which can readily flow into the prominence and depression of the metal upon the lamination on the metal to be mechanically engaged is preferably formed of a thermoplastic polyimide of the formulae 2a, 2b, 2c and 2d.

The two metallic layers, upon which the resin layers are laminated according to the present invention, are preferably formed of copper.

Also, the present invention provides a method for manufacturing a double-sided metallic laminate comprising simultaneously or sequentially applying a precursor of a low thermal expansion polyimide having a thermal expansion coefficient of  $5 \times 10^{-6}$  to  $2.5 \times 10^{-5}/^{\circ}\text{C}$  and a precursor of a

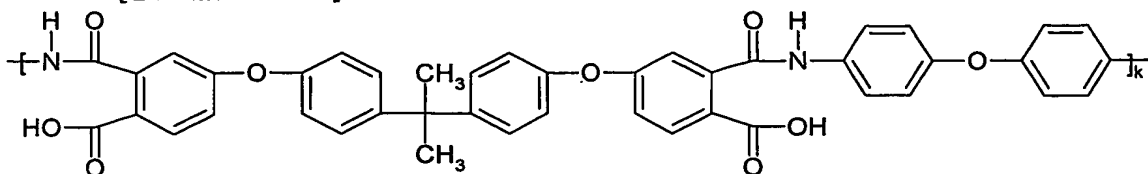
thermoplastic polyimide; or a precursor of a polyimide for improving adhesion with a metal, a precursor of a low thermal expansion polyimide having a thermal expansion coefficient of  $5 \times 10^{-6}$  to  $2.5 \times 10^{-5}/^{\circ}\text{C}$  and a precursor of a thermoplastic polyimide, on a metal foil to form one side of the double-sided metallic laminate, followed by drying and curing, and laminating another metal foil on the surface of the resin layer of a thermoplastic polyimide of the resulting one-sided metallic laminate comprising the resin layer of a low expansion polyimide and the resin layer of a thermoplastic polyimide; or the resin layer of a polyimide for improving adhesion with a metal, the resin layer of a low expansion polyimide having a thermal expansion coefficient of  $5 \times 10^{-6}$  to  $2.5 \times 10^{-5}/^{\circ}\text{C}$  and the resin layer of a thermoplastic polyimide sequentially laminated on the metal foil layer, to form the other side of the double-sided metallic laminate.

In order to prepare the polyimide resin layer for improving adhesion with a metal, a polyamic acid of a polyimide precursor is dissolved in an organic solvent to form a polyamic acid solution. The polyamic acid which is used for improving adhesion with a metal is preferably a polyamic acid containing a  $-\text{NH}-$  group, more preferably a polyamic acid including a compound of the formula 5. Also, as a precursor of the polyimide resin layer, it is

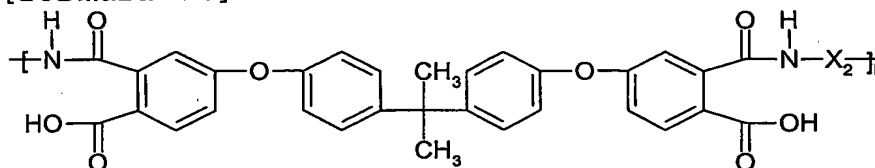
preferably a polyamic acid including the formulae 7a, 7b, 7c and 7d, which can readily flow into the prominence and depression of the metal upon the lamination on the metal to be mechanically engaged.

5

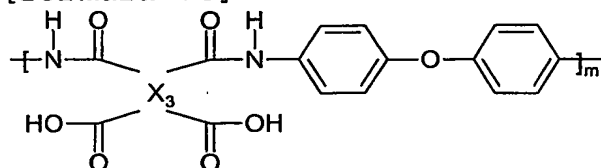
[formula 7a]



[formula 7b]

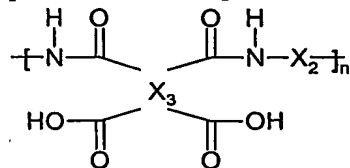


[formula 7c]



10

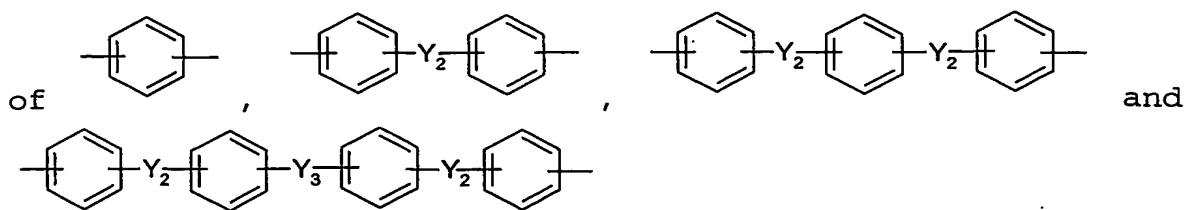
[formula 7d]



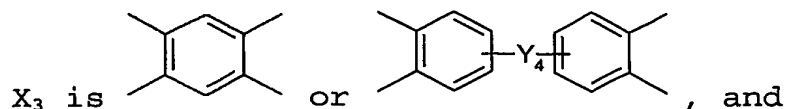
In the formulae 7a to 7d,  $k \geq 1$ ,  $l, m, n \geq 0$ ,  $l = m = n \neq 0$ ,  $k \geq l$ ,  $k + l > 1.5(m + n)$  and  $k + m > 1.5(l + n)$ ,

15

$X_2$  is at least one selected from the group consisting



$Y_2$  and  $Y_3$  are each independently or simultaneously -,  
-O-, -CO-, -S-, -SO<sub>2</sub>-, -C(CH<sub>3</sub>)<sub>2</sub>- or -CONH,



$Y_4$  is -, -O- or CO-.

5 The polyamic acid is preferably 10 to 30% by weight based on the total solution. If it is less than 10% by weight, the unnecessary amount of the solvent is increased. If it exceeds 30% by weight, the viscosity of the solution is increased, which makes it difficult to produce a uniform  
10 coating. The organic solvent to dissolve the polyamic acid is preferably a solvent having a polar group such as alcohol, ether, ketone, amide, sulfur monoxide and the like. Concrete examples include N-methyl-2-pyrrolidone (NMP), N,N-dimethyl acetamide (DMAc), N,N-dimethyl formamide (DMA),  
15 dimethyl sulfoxide (DMSO) and the like, which may be used alone or as a mixture of two or more thereof.

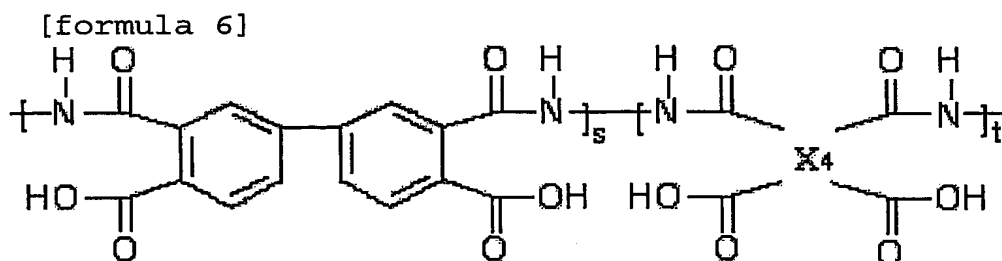
Further, the polyamic acid solution may be prepared by further adding an additive such as an antifoaming agent, an antigelling agent, a curing accelerator to facilitate  
20 the coating and curing or to improve other properties.

The polyamic acid solution thus obtained is applied using a die coater, a comma coater, a reverse comma coater, a gravure coater and the like, preferably to a thickness after drying and curing of 1 to 5  $\mu\text{m}$ . If the thickness is  
25 less than 1  $\mu\text{m}$ , the adhesion to the metal cannot be

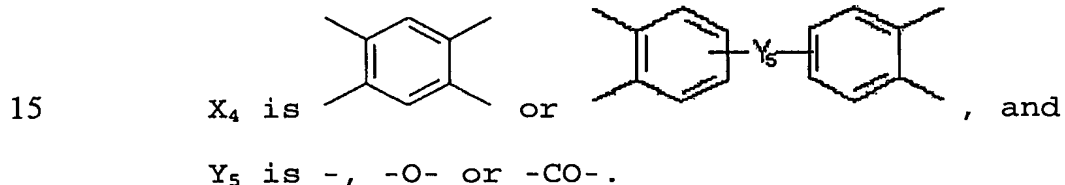
attained while if it exceeds 5  $\mu\text{m}$ , the thermal expansion coefficient of the resin layer of a low expansion polyimide is affected, thereby causing the curling.

After application, the coating is dried in an arch type oven, a floating type oven and the like at a temperature of lower than the boiling point of the solvent.

Also, in order to prepare the resin layer of a low expansion polyimide, a polyamic acid of a thermoplastic polyimide precursor is dissolved in an organic solvent to form a polyamic acid solution. The polyamic acid preferably comprises a copolymer of the formula 6.



In the formula 6,  $s > 1$ ,  $t > 0$  and  $s/t = 0.4 \sim 2.5$ ,



The preparation of the polyamic acid is the same as described for the polyamide for improving adhesion with a metal layer. The prepared polyamic acid solution is applied using a die coater, a comma coater, a reverse comma coater, a gravure coater and the like, preferably to a thickness after drying and curing of 15 to 50  $\mu\text{m}$ , and dried

in an arch type oven, a floating type oven and the like at a temperature of lower than the boiling point of the solvent.

Also, in order to prepare the resin layer of a thermoplastic polyimide, a polyamic acid of a thermoplastic polyimide precursor is dissolved in an organic solvent to form a polyamic acid solution. The thermoplastic polyimide precursor is preferably a polymer including the formulae 7a, 7b, 7c and 7d, more preferably, a copolymer of the formulae 7a to 7d, in which  $m, n = 0$  and  $X_2$  is the formula 3, or a copolymer of the formulae 7a to 7d, in which  $m, n = 0$  and  $X_2$  is the formula 4. The preparation of the polyamic acid is the same as described for the low expansion polyimide. The prepared polyamic acid solution is applied using a die coater, a comma coater, a reverse comma coater, a gravure coater and the like, preferably to a thickness after drying and curing of 1 to 5  $\mu\text{m}$ , and dried in an arch type oven, a floating type oven and the like at a temperature of lower than the boiling point of the solvent.

Alternatively, it is possible to simultaneously apply a solution of a precursor of a polyimide for improving adhesion with a metal, a solution of a precursor of a low thermal expansion polyimide and a solution of a precursor of a thermoplastic polyimide using a die coater, followed by drying.

As described above, precursors of a low thermal expansion polyimide and a thermoplastic polyimide; or precursors of a polyimide for improving adhesion with a metal, a low thermal expansion polyimide and a thermoplastic polyimide are applied on one side of a metal foil, dried and then cured to a temperature of 350°C. The curing is performed by slowly heating in an oven under a nitrogen atmosphere or in a vacuum, or by continuously passing through a high temperature under a nitrogen atmosphere.

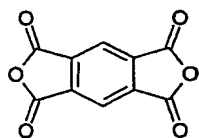
After curing, on the resin layer of a thermoplastic polyimide of the one-sided metallic laminate comprising a metal foil layer, a resin layer of a low expansion polyimide and a resin layer of a thermoplastic polyimide; or a metal foil layer, a resin layer of a polyimide for improving adhesion with a metal, a resin layer of a low expansion polyimide and a resin layer of a thermoplastic polyimide, which are sequentially laminated, another metal foil to form the other side of a double-sided metallic laminate is laminated by a batch type process using a press or a continuous type process using a role.

The lamination is performed preferably at a temperature of 300 to 350°C. If it is less than 300°C, the fluidity of the thermoplastic polyimide is reduced, whereby it is impossible to attain the desired adhesion after the

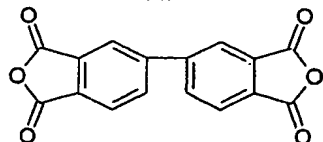
lamination. If it exceeds 350°C, wrinkles may form on the metal foil.

Now, the present invention will be described in further detail through the following examples, but is not  
5 limited thereto.

Meanwhile, the structures of monomers used in the Examples and Comparative examples are as follows.

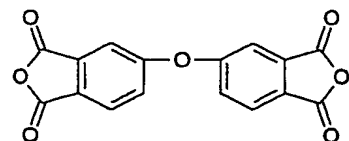


PMDA: pyromellitic acid dianhydride

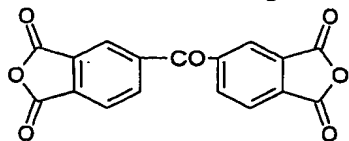


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DA: 3,3',4,4'-biphenyl tetracarboxylic acid dianhydride

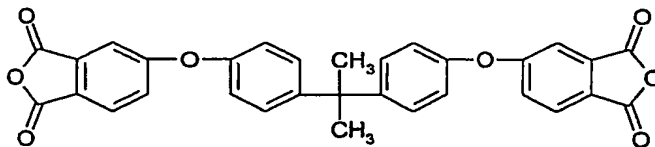


ODPA: 4,4'-oxy di-(phthalic acid anhydride)



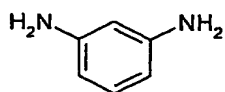
15

BTDA: 3,3',4,4'-benzophenon-tetracarboxylic acid dianhydride

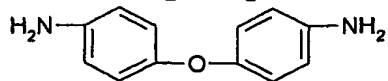


BPADA; bisphenol A dianhydride

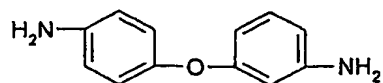




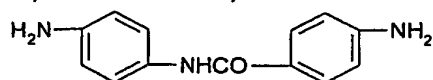
mPDA: m-phenyl diamine



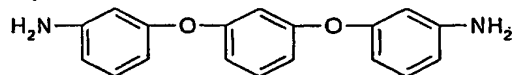
ODA: oxi-dianiline



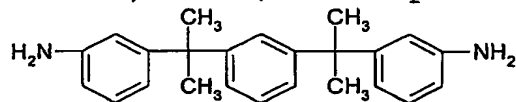
3,4'-ODA: 3,4'-oxi-dianiline



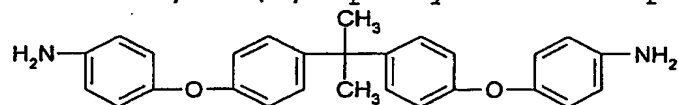
4,4'-diaminobenzanilide



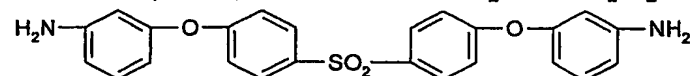
APB: 1,3-bis(3-aminophenoxy)benzene



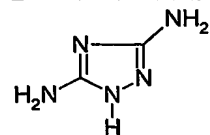
PDPDA: 4,4'-(1,3-phenylene diisopropylidene)dianiline



BAPP: 2,2-bis[4-(4-aminophenoxy)phenyl]propane



BAPSM: bis([4-(3-aminophenoxy)phenyl]sulfone)



TRIAZOLE

Examples 1 to 13 and Comparative examples 1 to 2:

20 Preparation of a double-sided metallic laminate comprising a resin layer of a low expansion polyimide and a resin

layer of a thermoplastic polyimide

## [Example 1]

In order to prepare a precursor of a low thermal expansion polyimide, 500 ml of N-methyl-2-pyrrolidone was put into a flask under a nitrogen atmosphere and 7.843g of m-PDA and 33.887g of 4,4'-ODA were thoroughly dissolved therein. Then, while maintaining a temperature at 0°C, 21.339g of BPDA and 36.930g of PMDA were added thereto and stirred for 24 hours to complete the polymerization.

Meanwhile, in order to prepare a precursor of a thermoplastic polyimide, 500 ml of N-methyl-2-pyrrolidone was put into a flask under a nitrogen atmosphere and 14.625g of ODA and 18.054g of m-PDA were added and thoroughly dissolved therein. Then, while maintaining a temperature at 0°C, 117.321g of BPADA was added thereto and stirred for 24 hours to complete the polymerization.

The polymerized low thermal expansion polyimide precursor was applied on a copper foil having a thickness of 12  $\mu\text{m}$  to the final thickness after curing of 23  $\mu\text{m}$  using a reverse comma coater and dried at 140°C for 7 minutes. After drying, on the copper foil having the low thermal expansion polyimide precursor coated, the polymerized thermoplastic polyimide precursor was applied to the final thickness after curing of 2  $\mu\text{m}$ , dried at 140°C, cured by continuously passing the product through temperatures of

180°C for 20 minutes, 250°C for 4 minutes and 350°C for 8 minutes and slowly cooled to form a one-sided metallic laminate comprising a low thermal expansion polyimide and a thermoplastic polyimide sequentially laminated on a copper foil.

The prepared one-sided metallic laminate is laminated with another copper foil using a laminator at a temperature of 320°C and a pressure of 15 kg/cm to form a double-sided metallic laminate comprising a copper foil, a resin layer of a low expansion polyimide, a resin layer of a thermoplastic polyimide and another copper foil, which are sequentially laminated. The product was examined for properties and the results are shown in Table 3.

[Examples 2 to 13 and Comparative examples 1 to 2]

Double-sided metallic laminates were prepared following the same method as described in Example 1, except that components of the monomers for the resin layer of a low expansion polyimide and the resin layer of a thermoplastic polyimide, their compositional ratio, thermal expansion coefficient (CTE), glass transition temperature (T<sub>g</sub>) of and thickness of the resin layers are as described in Tables 1 and 2, and examined for properties, and the results are shown in Table 3. The adhesion among the properties was measured according to JIS C5016 and the curl was examined by measuring the curl radius of a double-sided

metallic laminate with width and length of 100\*100mm.

[Table 1]

	Resin layer of low expansion polyimide									
	Component				Ratio (molar ratio)				CTE (10 <sup>-6</sup> /°C)	Thickn ess
	Anhydrid e (1)	Anhyd ride (2)	Amine (1)	Amin e (2)	Anhyd ride (1)	Anhyd ride (2)	Amine (1)	Amine (2)		PI1
Ex. 1	BPDA	PMDA	PDA	ODA	30	70	30	70	21	23
Ex. 2	BPDA	PMDA	PDA	ODA	30	70	70	30	16	21
Ex. 3	BPDA	OPDA	PDA	-	30	70	100	-	15	23
Ex. 4	BPDA	OPDA	PDA	-	50	50	100	-	16	22
Ex. 5	BPDA	BTDA	PDA	-	50	50	100	-	13	21
Ex. 6	BPDA	BTDA	PDA	-	30	70	100	-	16	22
Ex. 7	BPDA	BTDA	PDA	-	30	70	100	-	16	22
Ex. 8	BPDA	PMDA	PDA	-	70	30	100	-	8	19
Ex. 9	BPDA	PMDA	PDA	-	70	30	100	-	8	19
Ex. 10	BPDA	OPDA	PDA	-	50	50	100	-	16	21
Ex. 11	BPDA	BTDA	PDA	-	50	50	100	-	13	21
Ex. 12	BPDA	OPDA	PDA	-	30	70	100	-	15	22
Ex. 13	BPDA	BTDA	PDA	-	30	70	100	-	16	21
Comp	BPDA	PMDA	PDA	-	70	30	100	-	8	19
Comp	BPDA	PMDA	PDA	-	70	30	100	-	8	19

[Table 2]

	Resin layer of thermoplastic polyimide									
	Component				Ratio (molar ratio)				Tg (°C)	Thickn ess
	Anhydr ide (1)	Anhydri de (2)	Amine (1)	Amine (2)	Anhydr ide (1)	Anhydr ide (2)	Amine (1)	Amine (2)		PI2
Ex. 1	BPADA	-	ODA	mPDA	100	-	60	40	220	2

Ex. 2	BPADA	-	ODA	3,4-ODA	100	-	60	40	220	4
Ex. 3	BPADA	-	ODA	DAPB	100	-	90	10	237	2
Ex. 4	BPADA	-	ODA	APB	100	-	80	20	206	3
Ex. 5	BPADA	-	ODA	PDPBA	100	-	70	30	208	4
Ex. 6	BPADA	-	ODA	BAPP	100	-	70	30	205	3
Ex. 7	BPADA	-	ODA	BAPSM	100	-	80	20	212	3
Ex. 8	BPADA	PMDA	ODA	-	90	10	100	-	252	6
Ex. 9	BPADA	BPDA	ODA	-	85	15	100	-	230	6
Ex. 10	BPADA	ODPA	ODA	-	75	25	100	-	231	4
Ex. 11	BPADA	BTDA	ODA	-	75	25	100	-	226	4
Ex. 12	BPADA	ODPA	ODA	BAPP	80	20	80	20	219	3
Ex. 13	BPADA	BTDA	ODA	APB	70	30	70	30	208	4
Comp	BTDA	-	ODA	-	100	-	100	-	277	6
Comp	BPADA	-	ODA	-	100	-	100	-	220	6

[Table 3]

	Adhesion (kg/cm)	Curl (cm)		
		Before etching	After etching of one side	After etching both sides
Ex. 1	0.9	$\infty$	-70	30
Ex. 2	1.1	$\infty$	Almost flat	40
Ex. 3	1.4	$\infty$	Almost flat	45
Ex. 4	1.3	$\infty$	60	Almost flat
Ex. 5	1.8	$\infty$	Almost flat	60
Ex. 6	1.5	$\infty$	60	Almost flat
Ex. 7	1.5	$\infty$	55	Almost flat
Ex. 8	0.6	$\infty$	Almost flat	50
Ex. 9	0.9	$\infty$	Almost flat	50
Ex. 10	1.2	$\infty$	Almost flat	40
Ex. 11	1.6	$\infty$	Almost flat	60
Ex. 12	1.4	$\infty$	55	Almost flat
Ex. 13	1.3	$\infty$	Almost flat	60

Comp. Ex. 1	0.1	-	40	10
Comp. Ex. 2	0.2	$\infty$	Almost flat	50

As shown in Table 3, the metallic laminate of Examples 1 to 13 comprising a resin layer of a low expansion polyimide and a resin layer of a thermoplastic polyimide according to the present invention showed the 5  
adhesion more excellent than Comparative examples 1 to 2 using a resin layer of a thermoplastic polyimide having a structure different from the present invention and substantially had no curl before and after etching the 10  
copper foil. In Table 3, the adhesion is more excellent as the value is higher, no curl before etching is represented by  $\infty$ , no curl after etching is represented by the flatness and no curl is substantially observed as the absolute value of the curl data is higher.

15 Also, according to Examples polyimide type resins could be securely laminated on a metal foil without using a conventional acryl or epoxy adhesive. Further, it was noted that the use of a polyimide type resin provided flexibility and thermal resistance.

20 Examples 14 to 29 and Comparative examples 3 to 4:  
Preparation of a double-sided metallic laminate comprising a polyimide resin layer for improving adhesion with a metal,  
a resin layer of a low expansion polyimide and a resin

layer of a thermoplastic polyimide

## [Example 14]

In order to prepare a polyimide precursor for improving adhesion with a metal, 500 ml of N-methyl-2-pyrrolidone (NMP) was put into a flask under a nitrogen atmosphere and 28.924g of ODA, 14.824g of BAPP and 0.942g of Triazole were added and thoroughly dissolved therein. Then, while maintaining a temperature at 0°C, 12.442g of PMDA and 42.8684g of BTDA were added thereto and stirred for 24 hours to complete the polymerization.

In order to prepare a precursor of a low thermal expansion polyimide, 500 ml of N-methyl-2-pyrrolidone was put into a flask under a nitrogen atmosphere and 7.843g of m-PDA and 33.887g of 4,4'-ODA were thoroughly dissolved therein. Then, while maintaining a temperature at 0°C, 21.339g of BPDA and 36.930g of PMDA were added thereto and stirred for 24 hours to complete the polymerization.

Also, in order to prepare a precursor of a thermoplastic polyimide, 500 ml of N-methyl-2-pyrrolidone was put into a flask under a nitrogen atmosphere and 14.625g of ODA and 18.054g of m-PDA were added and thoroughly dissolved therein. Then, while maintaining a temperature at 0°C, 117.321g of BPADA was added thereto and stirred for 24 hours to complete the polymerization.

The polymerized polyimide precursor for improving

adhesion with a metal was applied on a copper foil having a thickness of 12  $\mu\text{m}$  to the final thickness after curing of 1  $\mu\text{m}$  using a reverse comma coater and dried at 140°C for 2 minutes. After drying, on the copper foil having the

5 polyimide precursor for improving adhesion with a metal coated, the polymerized low thermal expansion polyimide precursor was applied to the final thickness after curing of 22  $\mu\text{m}$  and dried at 140°C for 7 minutes. After drying, the polymerized thermoplastic polyimide precursor was

10 applied to the final thickness after curing of 2  $\mu\text{m}$ , dried at 140°C for 10 minutes, heated to 200°C for 6 minutes, maintained at 200°C for 30 minutes, heated to 350°C for 30 minutes, cured at 350°C for 15 minutes and slowly cooled to form a one-sided metallic laminate comprising a polyimide

15 for improving adhesion with a metal, a low thermal expansion polyimide and a thermoplastic polyimide sequentially laminated on a copper foil.

The prepared one-sided metallic laminate is laminated with another copper foil using a laminator at a temperature

20 of 320°C and a pressure of 15 kg/cm to form a double-sided metallic laminate comprising a copper foil, a resin layer of a polyimide for improving adhesion with a metal, a resin layer of a low expansion polyimide, a resin layer of a thermoplastic polyimide and another copper foil, which are

25 sequentially laminated. The product was examined for



properties and the results are shown in Table 7.

[Examples 15 to 29 and Comparative examples 3 to 4]

Double-sided metallic laminates were prepared following the same method as described in Example 1, except that components of the monomers for the resin layer of a polyimide for improving adhesion with a metal, the resin layer of a low expansion polyimide and the resin layer of a thermoplastic polyimide, their compositional ratio, thermal expansion coefficient (CTE), glass transition temperature (Tg) of and thickness of the resin layers are as described in Tables 4 to 6, and examined for properties, and the results are shown in Table 7. The adhesion among the properties was measured according to JIS C5016 and the curl was examined by measuring the curl radius of a double-sided metallic laminate with width and length of 100\*100mm.

[Table 4]

	Resin layer for improving adhesion with metal											
	Component					Ratio (molar ratio)					CTE (10 <sup>-6</sup> /°C)	Thic knes s
	Anhydr ide (1)	Anhydr ide (2)	Amin e (1)	Amin e (2)	Amine (3)	Anhy drid e (1)	Anhy drid e (2)	Amin e (1)	Amin e (2)	Amin e (3)		
Ex. 14	PMDA	BTDA	ODA	BAPP	Triaz ole	30	70	76	19	5	34	1
Ex. 15	PMDA	BTDA	ODA	BAPP	Triaz ole	50	50	76	19	5	30	1
Ex. 16	BPDA	BTDA	ODA	BAPP	Triaz ole	50	50	76	19	5	50	2
Ex. 17	BPDA	BTDA	PDA	BAPP	Triaz ole	50	50	76	19	5	22	3
Ex. 18	PMDA	BPDA	ODA	DABA	-	30	70	90	10	-	35	1
Ex. 19	PMDA	BTDA	ODA	BAPP	Triaz ole	30	70	76	19	5	34	3

Ex. 20	PMDA	BTDA	ODA	BAPP	Triazole	50	50	76	19	5	30	1
Ex. 21	BPDA	BTDA	ODA	BAPP	Triazole	50	50	76	19	5	50	4
Ex. 22	BPDA	BTDA	PDA	BAPP	Triazole	50	50	76	19	5	22	4
Ex. 23	PMDA	BPDA	ODA	DABA	-	30	70	90	10	-	35	2
Ex. 24	PMDA	BTDA	ODA	BAPP	Triazole	30	70	76	19	5	34	2
Ex. 25	PMDA	BTDA	ODA	BAPP	Triazole	50	50	76	19	5	30	1
Ex. 26	BPDA	BTDA	ODA	BAPP	Triazole	50	50	76	19	5	50	2
Ex. 27	BPADA	-	ODA	mPDA	-	100	-	60	40	40	220	1
Ex. 28	BPADA	-	ODA		BAPP	100	-	70	30	-	205	3
Ex. 29	BPADA	BTDA	ODA	-	-	75	25	100	-	-	226	3
Comp. Ex. 3	BTDA	-	ODA	-	-	100	-	100	-	-	277	4
Comp. Ex. 4	BPADA	-	ODA	-	-	100	-	100	-	-	220	-

[Table 5]

	Resin layer of low thermal expansion polyimide									
	Component				Ratio (molar ratio)				CTE (10 <sup>-6</sup> /°C)	Thicknes s
	Anhydrid e (1)	Anhydrid e (2)	Amin e (1)	Amin e (2)	Anhydrid e (1)	Anhydrid e (2)	Amin e (1)	Amin e (2)		
Ex. 14	BPDA	PMDA	PDA	ODA	30	70	30	70	21	22
Ex. 15	BPDA	PMDA	PDA	ODA	30	70	70	30	16	21
Ex. 16	BPDA	ODPA	PDA	-	30	70	100	-	16	20
Ex. 17	BPDA	ODPA	PDA	-	50	50	100	-	16	19
Ex. 18	BPDA	BTDA	PDA	-	50	50	100	-	13	20
Ex. 19	BPDA	BTDA	PDA	-	30	70	100	-	16	19
Ex. 20	BPDA	BTDA	PDA	-	30	70	100	-	16	20
Ex. 21	BPDA	PMDA	PDA	-	70	30	100	-	8	16
Ex. 22	BPDA	PMDA	PDA	-	70	30	100	-	8	16
Ex. 23	BPDA	ODPA	PDA	-	50	50	100	-	16	20
Ex. 24	BPDA	BTDA	PDA	-	50	50	100	-	13	19

Ex. 25	BPDA	ODPA	PDA	-	30	70	100	-	16	20
Ex. 26	BPDA	BTDA	PDA	-	30	70	100	-	16	20
Ex. 27	BPDA	PMDA	PDA	ODA	30	70	30	70	21	22
Ex. 28	BPDA	BTDA	PDA	-	50	50	100	-	13	20
Ex. 29	BPDA	BTDA	PDA	-	30	70	100	-	16	19
Comp	BPDA	PMDA	PDA	-	70	30	100	-	8	16
Comp	BPDA	PMDA	PDA	-	70	30	100	-	8	19

[Table 6]

	Resin layer of thermoplastic polyimide									
	Component				Ratio (molar ratio)				Tg (°C)	Thickness
	Anhydride (1)	Anhydride (2)	Amine (1)	Amine (2)	Anhydride (1)	Anhydride (2)	Amine (1)	Amine (2)		
Ex. 14	BPADA	-	ODA	mpDA	100	-	60	40	220	2
Ex. 15	BPADA	-	ODA	3,4'-ODA	100	-	60	40	220	3
Ex. 16	BPADA	-	ODA	DAPB	100	-	90	10	237	3
Ex. 17	BPADA	-	ODA	APB	100	-	80	20	206	3
Ex. 18	BPADA	-	ODA	PDPB A	100	-	70	30	208	4
Ex. 19	BPADA	-	ODA	BAPP	100	-	70	30	205	3
Ex. 20	BPADA	-	ODA	BAPS M	100	-	80	20	212	4
Ex. 21	BPADA	PMDA	ODA	-	90	10	100	-	252	5
Ex. 22	BPADA	BPDA	ODA	-	85	15	100	-	230	5
Ex. 23	BPADA	ODPA	ODA	-	75	25	100	-	231	3
Ex. 24	BPADA	BTDA	ODA	-	75	25	100	-	226	4
Ex. 25	BPADA	ODPA	ODA	BAPP	80	20	80	20	219	4
Ex. 26	BPADA	BTDA	ODA	APB	70	30	70	30	208	3
Ex. 27	BPADA	-	ODA	3,4'-ODA	100	-	60	40	220	2
Ex. 28	BPADA	-	ODA	BAPS M	100	-	80	20	212	3
Ex. 29	BPADA	-	ODA	3,4'-ODA	100	-	60	40	220	3
Comp	BTDA	-	ODA	-	100	-	100	-	277	5

Comp	BPADA	-	ODA	-	100	-	100	-	220	6
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[Table 7]

	Adhesion (kg/cm)		Curl (cm)			
	Adhesion part with metal	Adhesion part with thermoplastic polyimide	Before etching	After etching adhesion part with metal	After etching adhesion part with thermoplastic polyimide	After etching both sides
Ex. 14	1.0	0.9	$\infty$	20	Almost flat	10
Ex. 15	0.8	1.1	$\infty$	Almost flat	Almost flat	Almost flat
Ex. 16	1.1	1.4	$\infty$	Almost flat	Almost flat	Almost flat
Ex. 17	0.8	1.3	$\infty$	Almost flat	Almost flat	Almost flat
Ex. 18	0.8	1.8	$\infty$	Almost flat	Almost flat	Almost flat
Ex. 19	1.0	1.5	$\infty$	Almost flat	Almost flat	Almost flat
Ex. 20	0.8	1.5	$\infty$	Almost flat	Almost flat	Almost flat
Ex. 21	1.1	0.6	$\infty$	25	25	Almost flat
Ex. 22	0.8	0.9	$\infty$	Almost flat	15	3
Ex. 23	0.8	1.2	$\infty$	Almost flat	Almost flat	Almost flat
Ex. 24	1.0	1.6	$\infty$	Almost flat	Almost flat	25
Ex. 25	0.8	1.4	$\infty$	Almost flat	Almost flat	20
Ex. 26	1.1	1.3	$\infty$	Almost flat	Almost flat	Almost flat
Ex. 27	0.9	1.1	$\infty$	15	20	5
Ex. 28	1.5	1.5	$\infty$	Almost flat	Almost flat	Almost flat
Ex. 29	1.6	1.1	$\infty$	Almost flat	Almost flat	Almost flat
Comp. Ex. 3	0.8	0.1	$\infty$	12	18	Almost flat
Comp. Ex. 4	0.6	0.2	$\infty$	Almost flat	4	0.5

As shown in Table 7, the metallic laminate of

Examples 14 to 29 comprising a resin layer of a polyimide for improving adhesion with a metal, a resin layer of a low expansion polyimide and a resin layer of a thermoplastic polyimide according to the present invention showed the  
5 adhesion more excellent than Comparative examples 3 to 4 using a resin layer of a polyimide for improving adhesion with a metal and a resin layer of a thermoplastic polyimide having a structure different from the present invention and substantially had no curl before and after etching the  
10 copper foil. In Table 7, the adhesion is more excellent as the value is higher, no curl before etching is represented by  $\infty$ , no curl after etching is represented by the flatness and no curl is substantially observed as the absolute value of the curl data is higher.

15 Also, according to Examples polyimide type resins could be securely laminated on a metal foil without using a conventional acryl or epoxy adhesive. Further, it was noted that the use of a polyimide type resin provided flexibility and thermal resistance.

#### 20 Industrial Applicability

As described above, the double-sided metallic laminate according to the present invention, which is  
25 securely laminated without the use of an adhesive, has

excellent flexibility and thermal resistance and can prevent curl, is a useful invention suitably applicable to a printed circuit board of a small size electric appliance.